Ideas on Innovation

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HUMAN CAPITAL:
New skills for new jobs

Trained people in emerging occupations are essential for industrial economies to meet the challenge of rapid technological change. As Robert Reich observes in his influential book, *The Next American Frontier:*

"Financial capital formation is becoming a less important determinant of a nation's well-being than human capital formation. Financial capital is highly mobile. It crosses international borders with the speed of an electronic impulse... a nation's store of human capital is relatively immobile internationally, apart from a few high flying scientists and engineers. The skills, knowledge, and capacity for teamwork within a nation's labor force will determine that nation's collective standard of living."

University of Toronto's Edward Harvey (above) and John Blakely, Cornell University (left)

Grooming of "human capital," or work skills appropriate for a high-technology economy, requires the commitment of educational and training institutions as well as an effective manpower planning system.

Anticipating the need for highly responsive training, Canada recently submitted before the OECD that "techniques must be developed to identify emerging and declining skill needs, with enough advance warning to permit corrective action."[1]

In its role as policy advisor to government, industry and educational institutions, IDEA Corporation is helping to develop such techniques.

Working with the Ontario Manpower Commission (OMC), IDEA commissioned a survey, in late 1983, of current and future occupations in research-intensive sectors of Ontario manufacturing industries.

Designed and implemented by Edward Harvey of OISE and the University of Toronto, and John Blakely, a Ph.D. Candidate at Cornell University, this survey has yielded fresh insight into the characteristics of emerging and critical (in terms of demand) technical occupations. The picture includes educational requirements, recruitment patterns, degree of on-the-job training and expected growth level.

This issue of "Ideas on Innovation" presents the major findings of that survey.

SURVEYING THE FIELD

The survey was mailed mid-November 1983 to Ontario firms listed in the directories of the Canadian Advanced Technology Association (CATA), the Machinery and Equipment Manufacturers Association of Canada (MEMAC), and the Electrical and Electronic Manufacturers Association of Canada (EEMAC). The final survey target list consisted of 336 companies, representing a reasonable cross-section of high-technology enterprise in Ontario. R&D expenditures by these companies accounts for about 20% of manufacturing R&D outside the dominant communications (Northern Telecom) and aerospace industries.

Survey results are based on:

- A response rate of more than 30%
- A significant number of young companies—about 18% were founded after 1978 (Exhibit 1)
- 42% representation from electrical products manufacturers, 31% from machinery manufacturing, 16% business services and 11% in other industries (Exhibit 2)
- A majority of small firms (measured by employment and sales), with rapid growth in many between 1978-83 (Exhibit 3 and 4)

Overall, the survey data characterize the diversity of Ontario's technology firms.

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WHAT ARE THE JOBS?

The survey form identified 25 occupations considered "critical" (vital) by the OMC. In each occupation, companies were asked to provide information including numbers of persons employed in 1978 (or at start-up) and 1983, patterns of recruitment, promotion and staff development, importance of the occupation to the company and information on future hiring plans. Companies also were asked to specify any other occupations they regarded as critical.

The companies had 21 of these occupations. Exhibit 5 presents the following information for each of these critical occupations:

- Number of employees in 1983
- Growth in employment between 1978 and 1983
- Percent of firms regarding an occupation as somewhat or highly critical
- A ranking of future importance

A number of substantial differences can be observed among occupations. For example, some occupations have experienced considerable employment growth—CAD/CAM technicians being the most dramatic case—while others, such as civil engineers, have experienced relatively little growth. Similarly, substantial differences exist among occupations on their importance ratings and the percentage of firms regarding an occupation as somewhat or highly critical.

There are seven particularly critical occupations based on a combination of factors in Exhibit 5:

- Programmer/analysts
- Electrical engineers
- Engineering technicians
- Inspectors
- Mechanical engineers
- Foremen/women

EXHIBIT 1

Year company founded

	Percent	Number of respondents
1978 or before	81.4%	83
After 1978	18.6	19
Total	100.0	102

EXHIBIT 2

Industry groups represented by companies surveyed

	Percent	Number of respondents
Machinery Manufacturing (31)*	30.7%	31
Electrical Manufacturing (33)*	42.6	43
Services to Businesses (85/86)*	15.8	16
Other	10.9	11
Total	100.0	101

**Standard Industrial Classification (SIC) numbers*

EXHIBIT 3

Number of employees, 1983 and 1978 (or at start-up)

	1983		1978	
Number of employees	Percent	No. of respon.	Percent	No. of respon.
1—50	41.0%	41	54.6%	53
51—250	41.0	41	24.7	24
251+	18.0	18	20.6	20
Total	100.0	100	100.0	100

EXHIBIT 4

Sales of goods or services in most recent fiscal year

	Percent	Number of respondents
Up to $1 million	17.7%	16
$1 million—$5 million	25.6	23
$5 million—$10 million	14.4	13
$10 million—$50 million	31.1	28
$50 million +	11.1	10
Total	100.0	90

EXHIBIT 5

How critical do you think this job will be for the success of your business in the future?

	Number of employees (1983)	Employment growth index (1978 = 100)	% of firms that regard occupation as somewhat or highly critical	Importance index*
Assemblers	1,523	152.0	49.6%	3.5
Engineering technicians	863	164.4	88.7	4.0
Electrical engineers	682	188.4	90.9	4.5
Inspectors	467	137.0	68.9	3.9
Foremen/women	435	115.7	68.2	3.8
Programmer/analysts	425	201.4	95.2	4.5
Draftsmen/women	412	119.8	63.3	3.7
Mechanical engineers	383	143.4	78.9	4.1
Industrial engineers	127	123.3	87.3	3.8
Mechanics	120	181.8	67.3	3.0
Physicists	80	160.0	78.0	2.6
CAD/CAM technicians	65	1,300.0	100.0	3.8
Chemists	51	212.5	54.6	2.3
Chemical engineers	43	172.0	63.9	2.4
Math/statisticians	27	270.0	60.2	2.3
Aerospace engineers	16	400.0	51.3	1.6
Civil engineers	16	88.9	51.3	1.8
Metallurgical engineers	11	157.1	100.0	2.3
Physical science technicians	10	333.3	66.7	1.5
Life science technicians	6	200.0	100.0	1.3
Biologists	3	300.0	100.0	1.2
Psychologists	2	200.0	100.0	1.8

**The importance index is calculated as the average of responses for each occupation to the question: How critical do you think this job will be for the success of your business in the future?–with a reverse scale: highly critical = 5; somewhat critical = 4; no difference = 3; not very critical = 2; not critical at all = 1.*

"On-the-job training is by far the most frequently used form of employer-sponsored training in all the occupations identified."

EXHIBIT 6
What are the principal education requirements for this job?

	High school	Some college	College diploma	Some university	University degree	Other
Programmer/analysts	0.0%	2.3%	34.1%	13.6%	50.0%	0.0%
Electrical engineers	0.0	0.0	0.0	3.8	96.2	0.0
Engineering technicians	2.6	10.5	71.1	7.9	5.3	2.6
CAD/CAM technicians	6.7	13.3	73.3	0.0	6.7	0.0
Inspectors	38.9	30.6	13.9	2.8	8.3	5.6
Mechanical engineers	0.0	0.0	0.0	3.2	96.8	0.0
Foremen/women	50.0	26.2	11.9	0.0	0.0	11.9

EXHIBIT 7
What is your major source of recruits for entry-level positions in this occupation?

Occupation	Referrals	Canada Employment Centres	Overseas	Private placement	Universities and colleges	Private vocational	Newspapers	Other firms	Other	Number of respondents
Programmer/analysts	22.7%	4.5%	0.0%	13.6%	38.6%	0.0%	15.9%	2.3%	2.3%	44
Electrical engineers	14.0	0.0	2.0	18.0	28.0	0.0	24.0	14.0	0.0	50
Engineering technicians	12.5	4.2	0.0	14.6	41.7	2.1	18.8	2.1	4.2	48
CAD/CAM technicians	16.7	8.3	0.0	0.0	58.3	0.0	0.0	0.0	16.7	12
Inspectors	18.2	15.2	0.0	3.0	9.1	0.0	36.4	3.0	15.2	33
Mechanical engineers	7.4	0.0	3.7	18.5	44.4	0.0	18.5	3.7	3.7	27
Foremen/women	18.9	13.5	0.0	8.1	0.0	0.0	40.5	8.1	10.8	37

KEY OCCUPATIONS AND THEIR CHARACTERISTICS

Higher education

Exhibit 6 shows a wide range of educational requirements across the seven critical occupations. The professional engineering occupations (mechanical and electrical) are most likely to require a university degree (96.2% and 96.8% respectively). Programmer/analysts show a more diverse pattern. Although 50% of employers require a university degree for this job, 34.1% will accept a college diploma while 13.6% regard some university training as acceptable. In the case of CAD/CAM technicians and engineering technicians, college diplomas are the most frequently expected educational requirement (73.3% and 71.1% respectively). Only in the case of foremen/women and inspectors are relatively lower levels of education required.

Recruitment source

Employers also were asked about their major sources of recruitment for entry-level positions in each critical occupation. As may be seen from Exhibit 7, universities and colleges are the most important sources of entry-level

recruitment for CAD/CAM technicians (58.3%), mechanical engineers (44.4%), engineering technicians (41.7%), programmer/analysts (34.6%), and electrical engineers (28%). Universities and colleges are not an important recruitment source for foremen/women and inspectors. Two other moderately important recruitment sources are newspaper advertisements and referrals from friends and employees.

Company size makes a difference for recruitment sources used. Small firms do more than 64% of their recruitment through referrals compared with 30% in medium-sized firms and 28% in large firms. Small firms are less likely to use colleges and universities as a recruitment source (21%) compared with medium-sized firms (30%) and large firms (41%). This might suggest the need to integrate the small growth-oriented firms into recruitment networks centered around colleges and universities.

To what extent do companies meet their needs by internal recruitment practices? For each critical occupation, the survey asked, "Are holders of this job typically recruited from another job in your firm?" The extent of internal recruitment depends on the occupation; for example, Exhibit 8 shows that internal recruitment in the critical occupations ranges from 1.8% for electrical engineers to 75% for inspectors. In many organizations, for example, foremen/women and inspector jobs have been filled traditionally through internal placement. With more professionalized occupations, the process of certification and accreditation inhibit the scope for internal recruitment practices. As might be expected, the use of internal recruitment is greater in large firms.

EXHIBIT 8

Are holders of this job typically recruited from another job in your firm?

Occupation	Percent responding that job holders are typically recruited internally	Number of respondents
Programmer/analysts	10.6%	47
Electrical engineers	1.8	56
Engineering technicians	14.3	56
CAD/CAM technicians	46.7	15
Inspectors	75.0	36
Mechanical engineers	9.4	32
Foremen/women	74.4	43

"Job rotation is relatively little used and educational leave is almost non-existent."

EXHIBIT 9
Are holders of this job typically promoted to another job in this firm?

Occupation	Promotability Often	sometimes	Never	Number of respondents
Programmer/analysts	20.5%	64.1%	15.4%	39
Electrical engineers	16.7	66.7	16.7	48
Engineering technicians	13.7	68.6	17.6	51
CAD/CAM technicians	0.0	77.8	22.2	9
Inspectors	9.1	87.9	3.0	33
Mechanical engineers	18.5	63.0	18.5	27
Foremen/women	9.8	73.2	17.1	41

Employee development patterns

Two types of employee development were examined: promotion patterns and the use of employer-sponsored training.

Exhibit 9 shows the response to the question: "Are holders of this job typically promoted to another job in this firm?" When the "often" and "sometimes" categories are combined, there is relatively little difference in promotion patterns across occupations. At the extremes, for example, 22.2% of firms employing CAD/CAM technicians say they are never promoted (compared with 3% for inspectors). However, this should not be regarded as conclusive. The number of CAD/CAM technicians "never promoted" could be a result of the relative newness of the occupation—employees simply may not have had time to be promoted. For some critical occupations, promotion opportunities are better in large firms. These occupations include electrical and mechanical engineers, engineering technicians, inspectors and foremen/women. Company size is not a factor in promotion opportunities for programmer/analysts and CAD/CAM technicians.

On-the-job training is by far the most frequently used form of employer-sponsored training in all the occupations identified (Exhibit 10). The greatest differences among occupations are in the use of in-house training and off-site training. Employers place somewhat greater emphasis on off-site training for higher-skill, as opposed to lower-skill occupations. Job rotation is relatively little used and educational leave, with the exception of programmer/analyst, is almost non-existent.

The survey results suggest that if employer-sponsored training is used it takes traditional or well-established forms. It may be that these traditional forms of employer-sponsored training are less conducive to the development of boundary-spanning skills than more innovative training approaches such as job rotation and educational leave.

Future prospects

The survey asked employers about their future hiring intentions. For each critical occupation, employers were asked if, over the next two years, they planned new hiring; replace-

EXHIBIT 10

What types of employer-sponsored training do you use in connection with this job?

Occupation	On-the-job training	In-house training	Off-site training	Job rotation	Educational leave	Other	None
Programmer/analysts	83.0%	51.1%	68.1%	8.5%	10.6%	4.3%	2.1%
Electrical engineers	73.2	35.7	53.6	10.7	3.6	3.6	3.6
Engineering technicians	89.1	38.2	58.2	14.5	1.8	3.6	1.8
CAD/CAM technicians	76.5	29.4	64.7	11.8	0.0	0.0	0.0
Inspectors	80.6	36.1	38.9	16.7	2.8	2.8	2.8
Mechanical engineers	71.9	37.5	53.1	6.3	3.1	3.1	3.1
Foremen/women	81.8	36.4	34.1	11.4	0.0	2.3	4.5

ment hiring only; or staff reductions. Exhibit 11 shows the results.

Employers are much more likely to be planning new hiring than staff reductions. However, there are significant occupational differences in the amount of new hiring planned. Just over 87% of firms employing CAD/CAM technicians expect to hire new employees in this job. By contrast, only 29.3% of firms employing foremen/women plan to hire new employees in this job.

Small companies are more likely than their larger counterparts to be projecting new hiring activities over the next two years. This is consistent with the earlier observation that the survey sample includes a number of small, high-technology, growth-oriented firms.

Going beyond traditional skills

The survey companies were asked to identify, for each critical occupation, any unique or specialized skill requirements that clearly go beyond traditional training. Results indicate that the basic skills required to interface with technologically advanced machinery are, in many cases, well established in this sample of firms. In this respect, employees in the sample are perhaps somewhat more advanced than the labor force as a whole.

The firms reported that a combination of skills, such as sales and engineering experience, for example, is desirable not only for the professional engineering occupations, but also for programmer analysts, engineering technicians, inspectors (including quality control specialists and field service personnel) and CAD/CAM technicians (in a customer support role).

A new emphasis on marketing

Among the smaller growing firms the success of a product can have a major impact on the company's overall success. While this has always been true, an increasing emphasis on support services (e.g., software support, machine maintenance) greatly increases the skill requirements and number of people who are likely to be in contact with buyer firms. Instilling the importance of sales and marketing objectives in these people is often followed by recognition of the need to develop their sales and marketing skills.

Renewed interest in marketing a firm's goods and services may be a reflection of a certain economic reality—that professional and techni-

"There is a trend toward integrating the organization by training key personnel in roles that fit new organizational structures."

EXHIBIT 11

Over the next two years, do you anticipate—(1) new hiring in this job; (2) hiring only to replace people who leave this job; (3) a reduction in the number of people employed in this job?

Occupation	New hiring planned	Replacement hiring only	Reductions planned	Number of respondents
Programmer/analysts	73.9%	21.7%	4.3%	46
Electrical engineers	68.6	31.4	0.0	51
Engineering technicians	61.5	36.5	1.9	52
CAD/CAM technicians	87.5	12.5	0.0	16
Inspectors	48.6	48.6	2.9	35
Mechanical engineers	45.2	51.6	3.2	31
Foremen/women	29.3	63.4	7.3	41

cal people with sales and marketing skills are in short supply and that opportunities in sales exist for individuals from a wide range of technical and professional training. Second, it may reflect an employer's desire to integrate all of the company's objectives in the design of individual jobs. This helps minimize overhead by reducing staff levels and ensures better responsiveness of design to market needs.

A focus on integration

In addition, new emphasis is being put on skills that increase the integration of work functions and processes within each firm. This shows up in the frequent mention of the need for improved written and verbal communication skills for technical personnel, and the need for "people skills" in supervisory and managerial positions (particularly foremen/women).

Equally important, is a trend toward integrating the *organization* by training key personnel in roles that fit new organizational structures. In programmer/analyst occupations, for example, respondents emphasize knowledge in specific functional areas (company product lines, equipment or services), and the application of this specific knowledge to internal communications systems (manufacturing information systems and management information systems).

RETRAINING FOR THE NEW JOBS

Increased emphasis also is being put on technical retraining from older, traditional occupations to new occupations. This shows up among CAD/CAM technicians. In many cases they are draftspeople and graphic artists, while in some other cases they displace draftspersons and other traditional occupations. This also shows up in a restructuring of foremen/women jobs to emphasize "facilitation" skills rather than supervisory skills and to place more emphasis on communications and motivation skills as a basis for managing productivity improvement. In engineering occupations this is apparent, at times, with a significant transformation of training needs to fit new technological needs. Even while increasing technical requirements in each engineering discipline tend to set the disciplines apart, there is some convergence in key areas: the emphasis, for example, on value engineering, sales engineering and robotics in many engineering disciplines, the very similar training needs identified in mechanical and electrical engineering in such

areas as hardware/software, complex high technology man-machine systems, and the use and understanding of CAD equipment. Of course, significant differences remain among engineering disciplines. The point is, however, in certain key areas these differences may be a matter of degree rather than substance. In short, in these areas we may be observing an increasing convergence in one of the basic technological foundations of the discipline.

Custom-tailored training

By no means less important, is the evidence that a great deal of investment continues to be in training for requirements specific to each firm. From a policy perspective, these requirements are the most difficult to evaluate because we know little about the process by which these needs are generated; in some cases they may be "driven" by the introduction of new technology. Important policy questions can be raised about the sources of training, the availability of alternative types of training, and the methods of evaluation directed at achieving the effective transfer of a technology into a firm. In other cases specific educational and training decisions made by employers and employees will affect the decision made about technological innovations. In this case, the questions about training sources, alternatives and methods come from the perspective of the innovator; how can training facilitate innovative behavior by key persons in critical occupations?

Generic skills

The flexibility and integration objective stated by respondents (and supported by recent technological innovations) point to a need for a new set of generic skills. Generally, these new skill mixes imply some combination of computer literacy or programming skills in a technical area. However, they go beyond the technical to a new "boundary-spanning" focus. That is, training in each critical occupation is enhanced by a specific emphasis on the role that can be played in marketing, sales and enhancing internal and external communication. The need for people with these generic skills appears to be the most critical issue facing employers in the sample.

MEETING THE NEEDS IN CRITICAL OCCUPATIONS

The results of this survey suggest that employees in critical occupations need flexible and integrative training that will equip them with boundary-spanning capabilities in the performance of their work. For example, the quality control specialist who is willing and able to cross traditional job boundaries to achieve specific technical, administrative or marketing goals,

"Employees in critical occupations need flexible and integrative training that will equip them with boundary-spanning capabilities in the performance of their work."

or the specialist who is trained to take on a number of boundary-spanning roles.

There are, however, a number of barriers to the full realization of the sort of integrative training that is needed increasingly in critical occupations. There are economic barriers. The value-added may not be sufficient to meet demands for people with inter-disciplinary education. For example, the difference between starting salaries for entry-level electrical engineers with MBAs and those without MBAs may provide insufficient incentive for promising candidates to invest in the additional education.

Barriers also exist in professional licence requirements. The boundaries of professional and technical jobs may be determined—at least partly—by professional standards, traditions or practices. It may not be economic or feasible for firms to encourage professional or technical employees to move into areas (such as sales) that violate professional assumptions or that—in the short- and medium-term—do not hold out the possibility of a reasonable payoff.

Further barriers arise when companies do not maintain an adequate human resource planning data base. One of the key components of human resource planning is measuring the transition of people within firms. Measurement of these "flows" from one occupational level to another, or from one functionally unrelated occupation to another, provides a framework for evaluating existing organizational processes and for developing policies that effect significant change. One barrier to the development of integrative training is a lack of data on existing transition possibilities in the organization.

Company size also can have an impact on the development of critical occupation skills. The survey results indicate that small firms are characterized by different recruiting and recruitment source patterns and are also more likely to lack the training infrastructure resources required for the development of employees in critical occupations.

Other barriers to the realization of training requirements can revolve around the types of employer-sponsored training traditionally used. As the survey results show, job rotation is rarely used in professional and technical occupations, and educational leave even less so. These alternatives intuitively seem more conducive to integrative training. The fact that job rotation appears to be used rather more frequently in lower-skill jobs, where movement between occupations is more frequent, should not inhibit its expanded use in higher-skill professional and technical occupations. There may be a perception among employers that short-and medium-term productivity gains will not compensate for job rotation costs.

OVERCOMING THE BARRIERS

There are a number of strategies for overcoming the types of barriers just discussed. Strategies for overcoming economic barriers may rest in revising university and college curricula (for example, developing more experiments in combining engineering and business school curricula), engineering retraining combined with business school upgrading for engineers in areas that are less in demand, or increased technical education for business school students. Moreover, the data provide substantial evidence of another economically viable response—substitution. Certain key engineering functions may be taken over by technicians, analysts, mathematicians/statisticians or others. The sales function may be performed by highly trained technicians. Comprehensive human resource data bases can provide a basis for viable, rational substitution decisions.

Professional boundaries and licensing procedures need restructuring. This is a process issue that may be addressed through existing or new consultative channels involving employers, educators, professional associations, unions and government. This process may be supported by research, such as this study, that pinpoints specific needs.

Continued efforts should be made to promote more comprehensive and data-based approaches to human resource planning in firms. Careful evaluation of flows of human resoures and transition possibilities may greatly assist the integrative process. Specific transition possibilities (for example, draftsmen/women to CAD/CAM technicians) can be identified. Public (macro-level) human resource planning data bases may provide useful data—particularly to smaller firms that may not have the depth or variety of human resources in their own employ.

The special problems of smaller firms point to the need for special services or programs, provided perhaps by alliances of related smaller firms or by government. Such services could include training infrastructure supports and assistance to smaller firms in becoming integrated more effectively with a wider range of recruitment networks.

Similarly, support is required to stimulate adoption—in firms of all sizes—of a wider range of employer-sponsored training initiatives. Specific examples might include financial incentives for adoption of innovative measures such as job rotation and education leave.

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FOOTNOTES

[1]OECD, *Inter-governmental Conference on Employment Growth in the Context of Structural Change*, 1983, p. 14.

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